PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-241100
(43)Date of publication of application : 21.09.1993

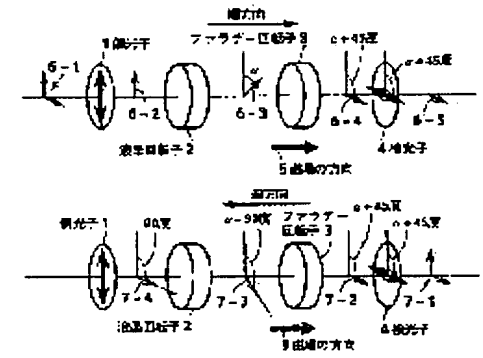
(51)Int.Cl. G02B 27/28

(21)Application number : 04-041273
(22)Date of filing : 27.02.1992

(71)Applicant : NIPPON TELEGR & TELEPH CORP <NTT>
(72)Inventor : AIZAWA SHIGEKI

(54) OPTICAL ISOLATOR

(57)Abstract:
PURPOSE: To provide the small-sized optical isolator which has no wavelength dependency.
CONSTITUTION: A rotary polarizing liquid crystal rotator 2 and a Faraday rotator 3 which change the polarizing direction of light are arranged between a polarizer 1 and an analyzer 4 which pass specific linear polarized light, and a magnetic field 5 is applied to the Faraday rotator 3; and the liquid crystal rotator 2 has exactly opposite rotational angle characteristics from a polarized light rotational angle depending upon the wavelength of the Faraday rotator 3 for reverse-directional incident light to the isolator, and the analyzer 4 has its polarizing direction slanted to the polarizer 1 by the sum of an angle αof polarized light rotation of reference wavelength by the liquid crystal rotator 2 and 45°.



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

Best Available Copy

Copyright (C); 1998,2003 Japan Patent Office

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The liquid crystal rotator of the optical activity which can change the polarization direction of light between the polarizer which passes the specific linearly polarized light, and an analyzer, The Faraday rotator to which the polarization direction can be changed with the MAG is arranged. And it is the optical isolator which equipped the above-mentioned Faraday rotator with the magnet for generating the Faraday effect. The above-mentioned liquid crystal rotator has an angle-of-rotation property completely contrary to the polarization angle of rotation for which it depended on the wavelength of the above-mentioned Faraday rotator to the incident light of the hard flow to the optical isolator concerned. The above-mentioned analyzer is an optical isolator characterized by only the sum of the polarization angle of rotation in the criteria wavelength by the above-mentioned liquid crystal rotator and 45 degrees having leaned the polarization direction to the above-mentioned polarizer.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the optical isolator aiming at a miniaturization.
[0002]
[Description of the Prior Art] In optical communication, the videodisk which can be written in using semiconductor laser etc. as the light source, the optical isolator which prevents the reflected light from an optical fiber, a lens system, and a connector end face is used.
[0003] The conventional optical isolator is shown in drawing 3 and 4. As shown in both drawings, a polarizer 101, the Xtal rotator 102 of optical activity, Faraday rotator 103, and an analyzer 104 arranged the optical axis, and carried out sequential arrangement, and this optical isolator is equipped with the magnet which a magnetic field 105 is given [magnet] and makes Faraday rotator 103 generate the Faraday effect and which is not illustrated. Here, the optical-activity Xtal rotator 102 compensates the polarization angle-of-rotation wavelength dependency of Faraday rotator 103. Moreover, only the sum of a polarization angle of rotation [in / in an analyzer 104 / the criteria wavelength of the optical-activity Xtal rotator 102] and 45 degrees has leaned the polarization direction to the polarizer 101.
[0004] signs that the light of criteria wavelength was introduced into such an optical isolator -- drawing 3 (A) and (B) It explains referring to. Drawing 3 (A) 106-1-5 show the situation of the polarization of light which goes to the forward direction, and after the light (106-1) of the criteria wavelength which goes to the forward direction turns into light (106-2) which is in agreement in the polarization direction with passage of a polarizer 101, it is outputted by the optical-activity Xtal rotator 102 in response to rotation of an include angle alpha (106-3). And this light (106-3) receives 45 rotations in this direction by Faraday rotator 103, and is the light which rotated only alpha+45 degrees to the polarization direction of a polarizer 101 after passage (106-4). Therefore, this light (106-4) passes the analyzer 104 with which the polarization direction leans and is allotted only alpha+45 degrees to the polarizer 101 (106-5).
[0005] Drawing 3 (B) 107-1-4 show the situation of the polarization of light which goes to hard flow, and only the light (107-2) which corresponds in the polarization direction of an analyzer 104 passes the analyzer 104 concerned. This light (107-2) is alpha+45 degrees (based on the hand of cut in the forward direction.) to the polarization direction of a polarizer 101. It is the same light which rotated below, and after Faraday rotator 103 passage, this light (107-2) receives 45 rotations, and turns into light (107-3) which rotated alpha+90 degrees to the polarization direction of a polarizer 101. And since this light (107-3) turns into light (107-4) which received rotation of -alpha by the optical-activity Xtal rotator 102 further, and rotated 90 degrees to the polarization direction of a polarizer 101, a polarizer 101 cannot be passed.
[0006] next, the case where a different light from criteria wavelength is introduced -- drawing 4 (A) and (B) It explains referring to. Drawing 4 (A) 108-1-5 show the situation of the polarization of light which goes to the forward direction, and after the light (108-1) of criteria wavelength and different wavelength turns into light (108-2) which was in agreement in the polarization direction with passage of a polarizer 101, it is outputted by the optical-activity Xtal rotator 102 in response to rotation of include-angle alpha+delta (108-3). And this light (108-3) receives rotation of 45 degree +delta in this direction by Faraday rotator 103, and is the light which rotated only alpha+2delta+45 degree to the polarization direction of a polarizer 101 after passage (108-4). therefore, the light (108-5) outputted from an analyzer 104 will become one times the reinforcement of cos2 2delta to the output light (108-3) from Faraday rotator 103, if loss of an analyzer 104 is disregarded.
[0007] Drawing 4 (B) 109-1-4 show the situation of the polarization of light which goes to hard flow. The light (109-2) which passes an analyzer 104 among the light (109-1) of criteria wavelength and different

wavelength is a light which is rotating alpha+45 degrees to the polarization direction of a polarizer 101, and this light turns into light (109-3) which rotated +90 alpha+delta to the polarization direction of a polarizer 101 after Faraday rotator 103 passage. Furthermore, since this light receives rotation only for - (alpha+delta) by the optical-activity Xtal rotator 102, since the light which passed the Xtal rotator 102 turns into light (109-4) which intersects perpendicularly in the polarization direction of a polarizer 101, it cannot pass a polarizer 101.

[0008]

[Problem(s) to be Solved by the Invention] As mentioned above, in order to compensate the polarization angle-of-rotation wavelength dependency of Faraday rotator 103 with the conventional optical isolator, the optical-activity Xtal rotator 102 is used. However, the problem of becoming large has the about double figures thickness of the Xtal rotator 102 required since it is small about double figures as compared with the polarization rotation ability of Faraday rotator 103, in order that the polarization rotation ability of the optical-activity Xtal rotator 102 may compensate the wavelength dependency of Faraday rotator 103 from Faraday rotator 103. That is, in the former, when it is going to compensate the wavelength dependency of Faraday rotator 103, there is a problem that the whole optical-isolator size will large-sized-ize.

[0009] In this invention, it aims at compensating the wavelength dependency of Faraday rotator and offering an optical isolator with small whole size in view of such a situation.

[0010]

[Means for Solving the Problem] The optical isolator of this invention which attains said purpose The liquid crystal rotator of the optical activity which can change the polarization direction of light between the polarizer which passes the specific linearly polarized light, and an analyzer, The Faraday rotator to which the polarization direction can be changed with the MAG is arranged. And it is the optical isolator which equipped the above-mentioned Faraday rotator with the magnet for generating the Faraday effect. The above-mentioned liquid crystal rotator has an angle-of-rotation property completely contrary to the polarization angle of rotation for which it depended on the wavelength of the above-mentioned Faraday rotator to the incident light of the hard flow to the optical isolator concerned. The above-mentioned analyzer is characterized by only the sum of the polarization angle of rotation in the criteria wavelength by the above-mentioned liquid crystal rotator and 45 degrees having leaned the polarization direction to the above-mentioned polarizer.

[0011]

[Function] A polarization angle of rotation becomes reverse in the forward direction and hard flow, and, as for Faraday rotator, there is a wavelength dependency in this polarization angle of rotation. On the other hand, a liquid crystal rotator has the polarization angle of rotation in which a polarization angle of rotation has the same and, same magnitude wavelength dependency as Faraday rotator in the forward direction and hard flow. Therefore, the wavelength dependency of Faraday rotator is compensated by the liquid crystal rotator of optical activity.

[0012]

[Example] Hereafter, this invention is explained based on an example.

[0013] The optical isolator of this example is shown in drawing 1 and 2. As shown in both drawings, this optical isolator carried out sequential arrangement of a polarizer 1, the liquid crystal rotator 2 of optical activity, Faraday rotator 3, and the analyzer 4, where that optical axis is arranged, and is equipped with the magnet which a magnetic field 5 is given [magnet] and makes Faraday rotator 3 generate the Faraday effect and which is not illustrated. Here, the optical-activity liquid crystal rotator 2 compensates the polarization angle-of-rotation wavelength dependency of Faraday rotator 3. Moreover, only the sum of a polarization angle of rotation and 45 ** has leaned the polarization direction to the polarizer 1. [in / in an analyzer 4 / the criteria wavelength of the optical-activity liquid crystal rotator 2]

[0014] Here, the optical-activity liquid crystal rotator 2 has the property of always rotating the passing light in this direction. That is, the light of criteria wavelength is drawing 1 (A). In passing to the forward direction so that it may be shown, only alpha receives rotation, and it is drawing 1 (B). If it is based on the hand of cut of the forward direction when passing to hard flow so that it may be shown - Only alpha will receive rotation. Moreover, it has set up so that the polarization angle of rotation of the optical-activity liquid crystal rotator 2 may compensate the wavelength dependency of Faraday rotator 3 depending on wavelength. That is, it is drawing 2 (A) by making the same the increment in the polarization angle of rotation depending on the wavelength of Faraday rotator 3 and the optical-activity liquid crystal rotator 2 (decrement). Although only 2delta is rotated too much from criteria wavelength in the forward direction so that it may be shown, it is drawing 2 (B). In hard flow, a wavelength dependency will be offset by Faraday rotator 3 and the optical-

activity liquid crystal rotator 2 so that it may be shown.
[0015] The twisted pneumatic (TN) liquid crystal as an example of the optical-activity liquid crystal rotator 2 has the transmission coefficient T of light shown by the degree type.
[0016]
[Equation 1]

$$T = \frac{\sin^2\left(\frac{\pi}{2}\sqrt{1+u^2}\right)}{1+u^2}$$

[0017] Here, it is u=2 ddeltan/lambda and d is [a refractive-index difference and lambda of the thickness of liquid crystal and deltan] the wavelength of light. Although it turns out that the permeability of light changes with wavelength from the upper type, this is for a polarization angle of rotation to be dependent on wavelength. That is, by using this property, as mentioned above, the wavelength dependency of Faraday rotator 3 can be compensated. And about double figures thickness of the optical-activity liquid crystal rotator 2 can be made small compared with the Xtal rotator, and can attain the miniaturization of the optical isolator itself. In addition, it cannot be overemphasized that the liquid crystal rotator 2 is not what is limited to the above-mentioned TN liquid crystal.
[0018] signs that the light of criteria wavelength was introduced into the optical isolator of this example -- drawing 1 (A) and (B) It explains referring to. Drawing 1 (A) 6-1-5 show the situation of the polarization of light which goes to the forward direction, and after the light (6-1) of the criteria wavelength which goes to the forward direction turns into light (6-2) which is in agreement in the polarization direction with passage of a polarizer 1, it is outputted by the optical-activity liquid crystal rotator 2 in response to rotation of an include angle (6-3). And this light (6-3) receives 45 rotations in this direction by Faraday rotator 3, and is the light which rotated only alpha+45 degrees to the polarization direction of a polarizer 1 after passage (6-4). Therefore, this light (6-4) passes the analyzer 4 with which the polarization direction leans and is allotted only alpha+45 degrees to the polarizer 1 (6-5).
[0019] Drawing 1 (B) 7-1-4 show the situation of the polarization of light which goes to hard flow, and only the light (7-2) which corresponds in the polarization direction of an analyzer 4 passes the analyzer 4 concerned. This light (7-2) is alpha+45 degrees (based on the hand of cut in the forward direction.) to the polarization direction of a polarizer 1. It is the same light which rotated below, and after Faraday rotator 3 passage, this light (7-2) receives 45 rotations, and turns into light (7-3) which rotated alpha+90 degrees to the polarization direction of a polarizer 1. And since this light (7-3) turns into light (7-4) which received rotation of -alpha by the optical-activity liquid crystal rotator 2 further, and rotated 90 degrees to the polarization direction of a polarizer 1, a polarizer 1 cannot be passed.
[0020] next, the case where a different light from criteria wavelength is introduced -- drawing 2 (A) and (B) It explains referring to. Drawing 2 (A) 8-1-5 show the situation of the polarization of light which goes to the forward direction, and after the light (8-1) of criteria wavelength and different wavelength turns into light (8-2) which was in agreement in the polarization direction with passage of a polarizer 1, it is outputted by the optical-activity liquid crystal rotator 2 in response to rotation of include-angle alpha+delta (8-3). And this light (8-3) receives rotation of 45 degree +delta in this direction by Faraday rotator 3, and is the light which rotated only alpha+2delta+45 degree to the polarization direction of a polarizer 1 after passage (8-4). therefore, the light (8-5) outputted from an analyzer 4 will become one times the reinforcement of cos2 2delta to the output light (8-3) from Faraday rotator 3, if loss of an analyzer 4 is disregarded.
[0021] Drawing 2 (B) 9-1-4 show the situation of the polarization of light which goes to hard flow. The light (9-2) which passes an analyzer 4 among the light (9-1) of criteria wavelength and different wavelength is a light which is rotating alpha+45 degrees to the polarization direction of a polarizer 1, and this light turns into light (9-3) which rotated +90 alpha+delta to the polarization direction of a polarizer 1 after Faraday rotator 3 passage. Furthermore, since this light receives rotation only for - (alpha+delta) by the optical-activity liquid crystal rotator 2, since the light which passed the liquid crystal rotator 2 turns into light (9-4) which intersects perpendicularly in the polarization direction, it cannot pass a polarizer 1.
[0022] As explained above, the optical isolator of this example compensates the wavelength dependency of Faraday rotator 3 with the liquid crystal rotator 2, and can call it a small optical isolator without the wavelength dependency of incident light. In addition, in the above-mentioned configuration, it cannot be overemphasized that the same effectiveness is acquired in arrangement of Faraday rotator 3 and the liquid crystal rotator 2 even if reverse.

[0023]
[Effect of the Invention] As explained above, the polarization angle of rotation over wavelength has amended the polarization angle-of-rotation wavelength dependency of Faraday rotator using a completely reverse liquid crystal rotator to the polarization angle of rotation of Faraday rotator, and an optical isolator without a wavelength dependency can be constituted. under the present circumstances, since polarization rotation ability of a liquid crystal rotator can be made larger than Faraday rotator, it can come out to make thin thickness for compensating the wavelength dependency of Faraday rotator, and, so, it can make size of the whole optical isolator small.

[Translation done.]

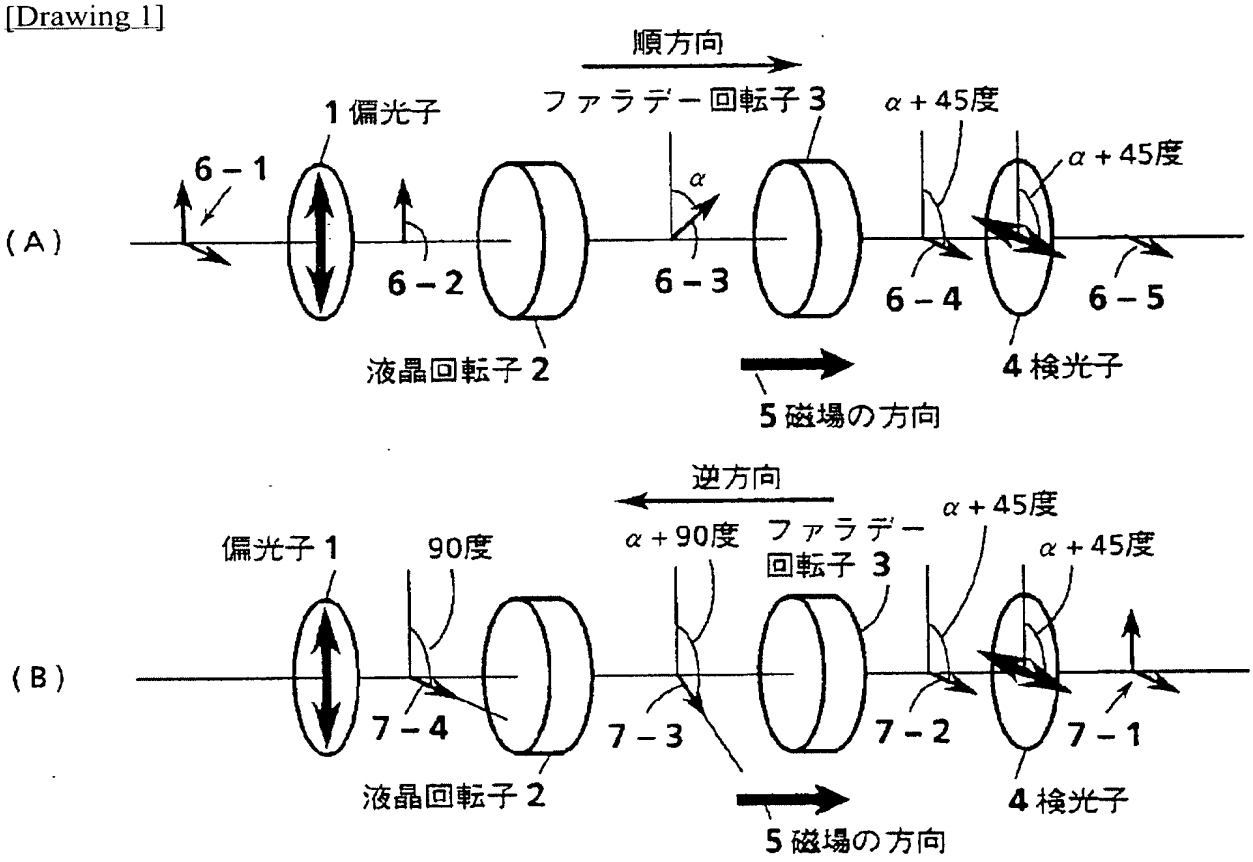
* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

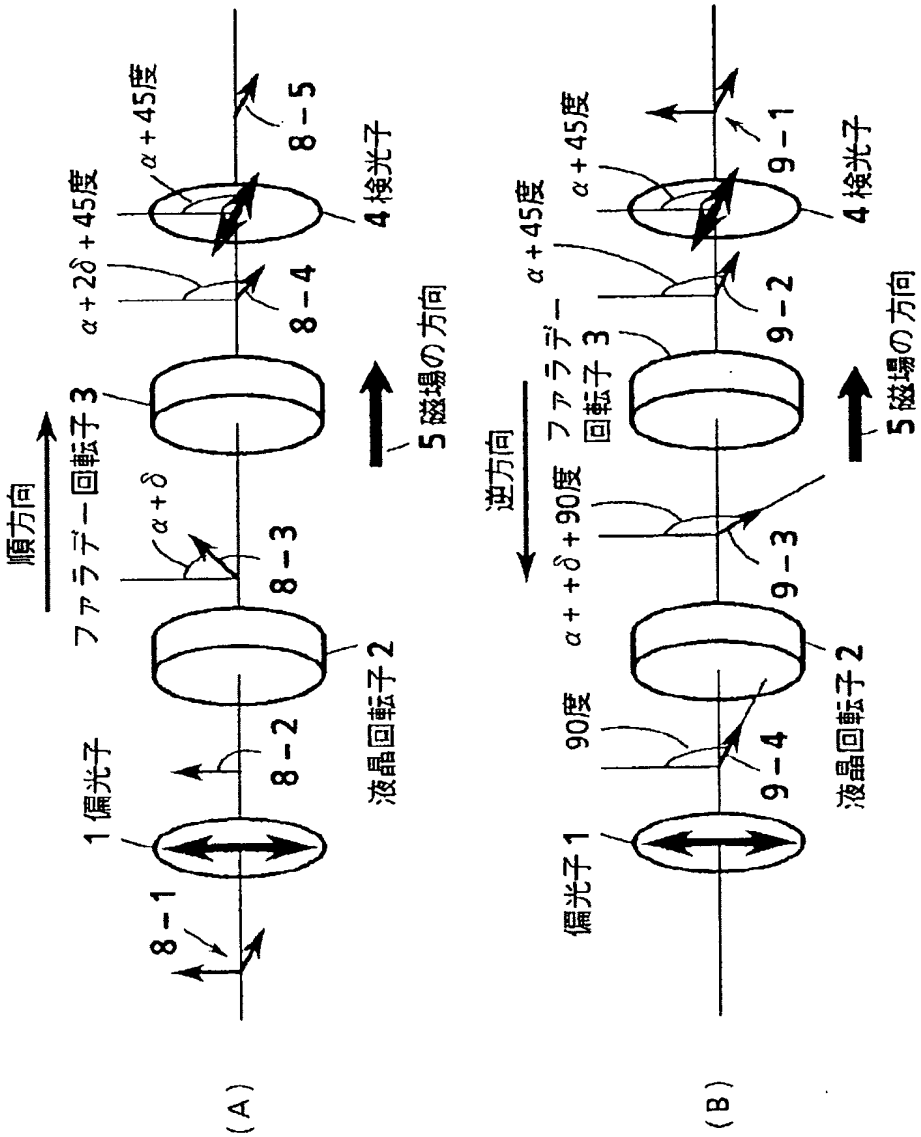
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

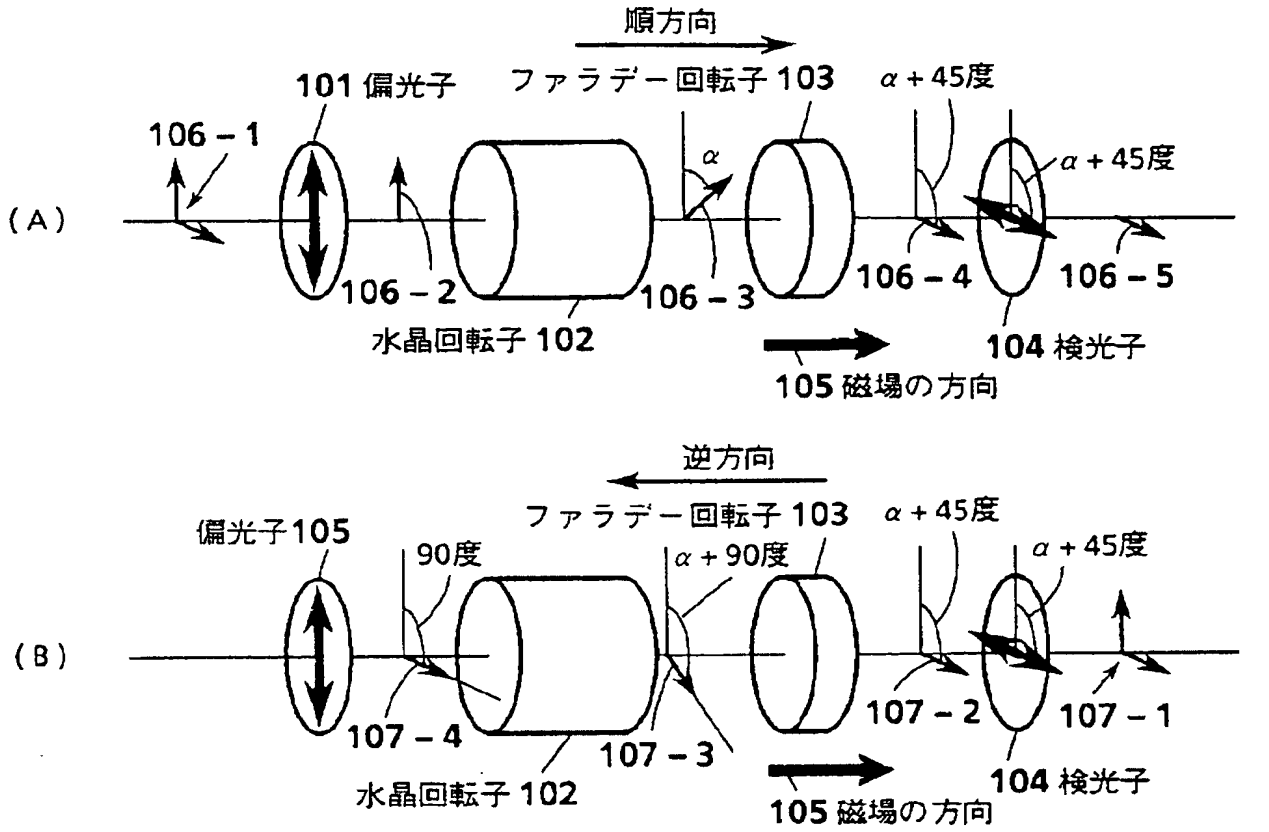
[Drawing 1]



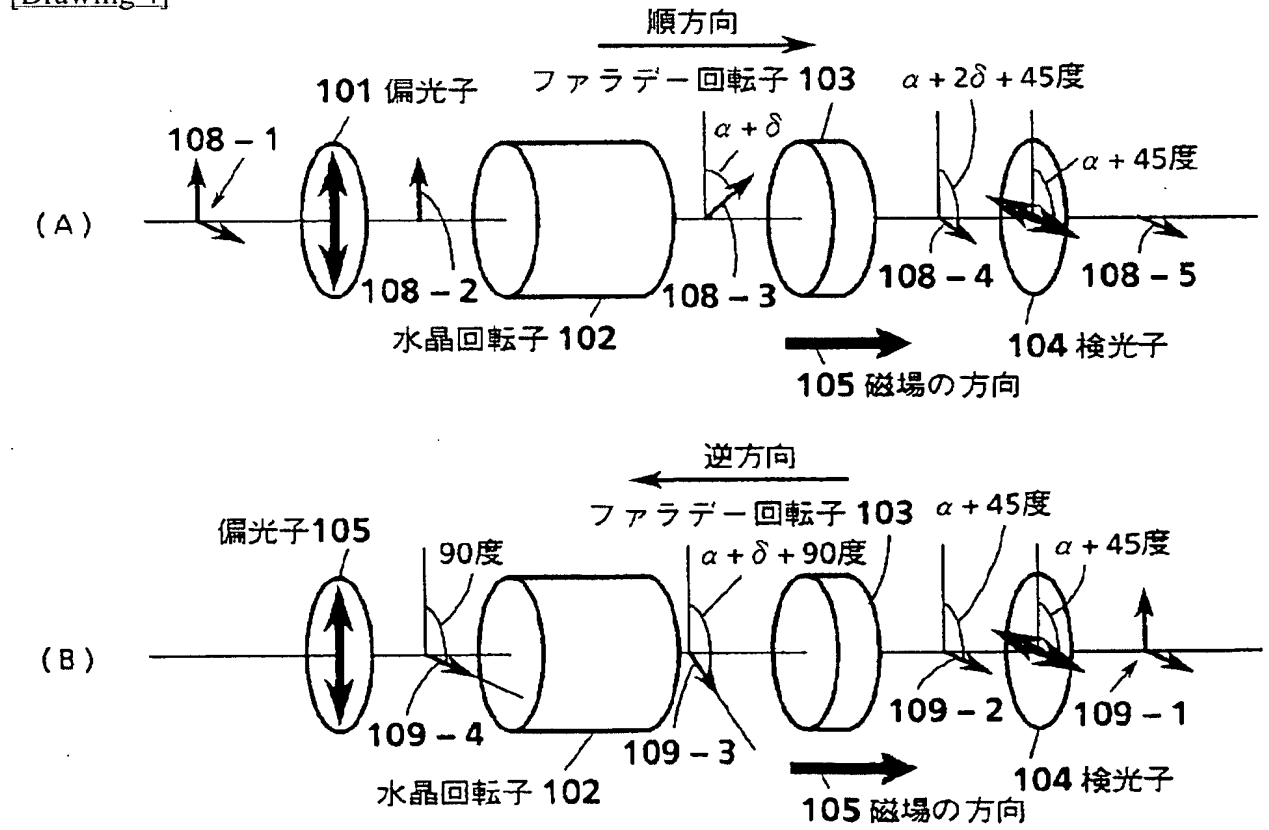
[Drawing 2]


順方向
1 偏光子
8－1
8－2
液晶回転子 2
ファラデー回転子 3
α＋δ
8－3
α＋2δ＋45度
8－4
α＋45度
8－5
4 検光子
5 磁場の方向
(A)
逆方向
偏光子 1
90度
α＋＋δ＋90度
9－4
9－3
液晶回転子 2
ファラデー回転子 3
α＋45度
9－2
α＋45度
9－1
4 検光子
5 磁場の方向
(B)

[Drawing 3]



[Drawing 4]



[Translation done.]

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 05-241100
(43)Date of publication of application : 21.09.1993

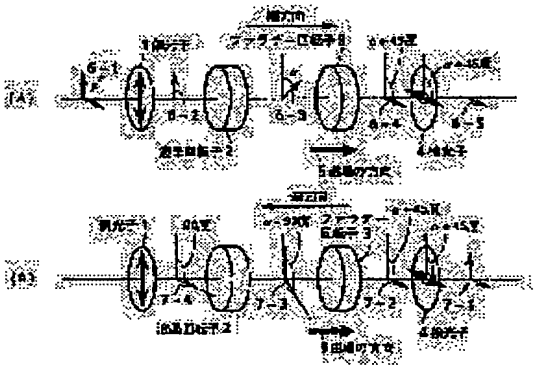
(51)Int.Cl. G02B 27/28

(21)Application number : 04-041273
(22)Date of filing : 27.02.1992

(71)Applicant : NIPPON TELEGR & TELEPH CORP <NTT>
(72)Inventor : AIZAWA SHIGEKI

(54) OPTICAL ISOLATOR

(57)Abstract:
PURPOSE: To provide the small-sized optical isolator which has no wavelength dependency.
CONSTITUTION: A rotary polarizing liquid crystal rotator 2 and a Faraday rotator 3 which change the polarizing direction of light are arranged between a polarizer 1 and an analyzer 4 which pass specific linear polarized light, and a magnetic field 5 is applied to the Faraday rotator 3; and the liquid crystal rotator 2 has exactly opposite rotational angle characteristics from a polarized light rotational angle depending upon the wavelength of the Faraday rotator 3 for reverse-directional incident light to the isolator, and the analyzer 4 has its polarizing direction slanted to the polarizer 1 by the sum of an angle αof polarized light rotation of reference wavelength by the liquid crystal rotator 2 and 45° .



LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

http://www6.ipdl.jpo.go.jp/Tokujitu/tj...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f///////

(19)日本国特許庁（ＪＰ）　(12)公開特許公報（Ａ）　(11)特許出願公開番号

特開平5－241100

(43)公開日　平成５年(1993)９月21日

(51)Int.Cl.[5]	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｇ０２Ｂ　27/28		Ａ　9120－2Ｋ		

審査請求　未請求　請求項の数１(全　８　頁)

(21)出願番号　特願平4－41273

(22)出願日　平成４年(1992)２月27日

(71)出願人　000004226
日本電信電話株式会社
東京都千代田区内幸町一丁目１番６号

(72)発明者　相澤　茂樹
東京都千代田区内幸町一丁目１番６号　日本電信電話株式会社内

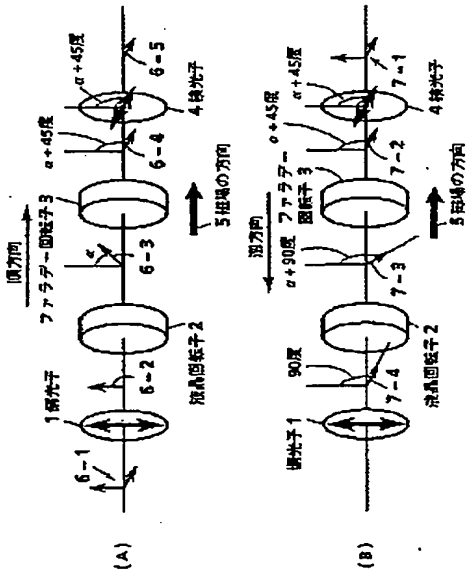
(74)代理人　弁理士　光石　俊郎

(54)【発明の名称】　光アイソレータ

(57)【要約】

【目的】　波長依存性のない小形の光アイソレータを提供する。

【構成】　特定の直線偏光を通過させる偏光子１及び検光子４の間に光の偏光方向を変化させることができる旋光性の液晶回転子２と、ファラデー回転子３とを配置し、且つファラデー回転子３には磁場５を与え．液晶回転子は当該アイソレータへの逆方向の入射光に対して上記ファラデー回転子３の波長に依存した偏光回転角と全く逆の回転角特性を有し．検光子４は液晶回転子２による基準波長における偏光回転角αと４５度との和だけ偏光子１に対して偏光方向を傾ける。



02/11/21 午前 09:59

http://www6.ipdl.jpo.go.jp/tjcontentbs...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f///////

1

【特許請求の範囲】

【請求項１】　特定の直線偏光を通過させる偏光子及び検光子の間に、光の偏光方向を変化させることができる旋光性の液晶回転子と、磁気によって偏光方向を変化させることができるファラデー回転子とを配置し、且つ上記ファラデー回転子にファラデー効果を発生させるための磁石を具えた光アイソレータであって、上記液晶回転子は当該光アイソレータへの逆方向の入射光に対して上記ファラデー回転子の波長に依存した偏光回転角と全く逆の回転角特性を有し、上記検光子は上記液晶回転子による基準波長における偏光回転角と４５度との和だけ上記偏光子に対して偏光方向を傾けてあることを特徴とする光アイソレータ。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は、小形化を図った光アイソレータに関する。

【０００２】

【従来の技術】半導体レーザ等を光源として用いる光通信、書き込み可能なビデオディスク等においては、光ファイバ、レンズ系、コネクタ類端面からの反射光を防止する光アイソレータが用いられる。

【０００３】従来の光アイソレータを図３，４に示す。両図に示すように、この光アイソレータは偏光子１０１、旋光性の水晶回転子１０２，ファラデー回転子１０３及び検光子１０４が光軸をそろえて順次配置したものであり、磁場１０５を与えてファラデー回転子１０３にファラデー効果を発生させる図示しない磁石を具えている。ここで、旋光性水晶回転子１０２はファラデー回転子１０３の偏光回転角波長依存性を補償するものである。また、検光子１０４は、旋光性水晶回転子１０２の基準波長における偏光回転角と４５度との和だけ偏光子１０１に対して偏光方向を傾けてある。

【０００４】このような光アイソレータに基準波長の光を導入した様子を図３(A),(B) を参照しながら説明する。図３(A) の１０６－１～５は順方向に進む光の偏光の様子を示し、順方向に進む基準波長の光（１０６－１）は偏光子１０１の通過によりその偏光方向に一致する光（１０６－２）となった後、旋光性水晶回転子１０２により角度αの回転を受けて出力される（１０６－３）。そして、この光（１０６－３）はファラデー回転子１０３により同方向に４５度の回転を受け、通過後には偏光子１０１の偏光方向に対してα＋４５度だけ回転した光となっている（１０６－４）。よって、この光（１０６－４）は、偏光子１０１に対して偏光方向がα＋４５度だけ傾けて配されている検光子１０４を通過する（１０６－５）。

【０００５】図３(B) の１０７－１～４は逆方向に進む光の偏光の様子を示し、逆方向に進む基準波長の光（１０７－１）は検光子１０４の偏光方向に一致する光（１０７－２）のみ当該検光子１０４を通過する。この光（１０７－２）は偏光子１０１の偏光方向に対してα＋４５度（順方向での回転方向を基準とする。以下同じ）回転した光であり、この光（１０７－２）はファラデー回転子１０３通過後には４５度の回転を受け、偏光子１０１の偏光方向に対してα＋９０度回転した光（１０７－３）となる。そしてこの光（１０７－３）はさらに旋光性水晶回転子１０２により－αの回転を受け、偏光子１０１の偏光方向に対して９０度回転した光（１０７－４）となるので、偏光子１０１を通過することはできない。

【０００６】次に、基準波長と異なる光を導入した場合を図４(A),(B) を参照しながら説明する。図４(A) の１０８－１～５は順方向に進む光の偏光の様子を示し、基準波長と異なる波長の光（１０８－１）は偏光子１０１の通過によりその偏光方向に一致した光（１０８－２）となった後、旋光性水晶回転子１０２により角度α＋δの回転を受けて出力される（１０８－３）。そして、この光（１０８－３）はファラデー回転子１０３により同方向に４５度＋δの回転を受け、通過後には偏光子１０１の偏光方向に対してα＋２δ＋４５度だけ回転した光となっている（１０８－４）。したがって、検光子１０４から出力される光（１０８－５）は検光子１０４の損失を無視すると、ファラデー回転子１０３からの出力光（１０８－３）に対して$\cos^2 2\delta$倍の強度となる。

【０００７】図４(B) の１０９－１～４は逆方向に進む光の偏光の様子を示している。基準波長と異なる波長の光（１０９－１）のうち、検光子１０４を通過する光（１０９－２）は偏光子１０１の偏光方向に対してα＋４５度回転している光であり、この光はファラデー回転子１０３通過後には偏光子１０１の偏光方向に対してα＋δ＋９０度回転した光（１０９－３）となる。さらに、この光は旋光性水晶回転子１０２により－（α＋δ）だけ回転を受けるので、水晶回転子１０２を通過した光は偏光子１０１の偏光方向に直交する光（１０９－４）となるため、偏光子１０１を通過することはできない。

【０００８】

【発明が解決しようとする課題】前述したように、従来の光アイソレータでは、ファラデー回転子１０３の偏光回転角波長依存性を補償するために旋光性水晶回転子１０２を用いている。しかし、旋光性水晶回転子１０２の偏光回転能は、ファラデー回転子１０３の偏光回転能に比較して二桁程度小さいため、ファラデー回転子１０３の波長依存性を補償するために必要な水晶回転子１０２の厚みもファラデー回転子１０３より二桁程度大きくなってしまうという問題がある。すなわち、従来においては、ファラデー回転子１０３の波長依存性を補償しようとすると、光アイソレータの全体サイズが大形化してしまうという問題がある。

02/11/21 午前 10:00

http://www6.ipdl.jpo.go.jp/tjcontentbs...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f//////

【０００９】本発明ではこのような事情に鑑み、ファラデー回転子の波長依存性を補償し、且つ全体サイズの小さい光アイソレータを提供することを目的とする。

【００１０】

【課題を解決するための手段】前記目的を達成する本発明の光アイソレータは、特定の直線偏光を通過させる偏光子及び検光子の間に、光の偏光方向を変化させることができる旋光性の液晶回転子と、磁気によって偏光方向を変化させることができるファラデー回転子とを配置し、且つ上記ファラデー回転子にファラデー効果を発生させるための磁石を具えた光アイソレータであって、上記液晶回転子は当該光アイソレータへの逆方向の入射光に対して上記ファラデー回転子の波長に依存した偏光回転角と全く逆の回転角特性を有し、上記検光子は上記液晶回転子による基準波長における偏光回転角と４５度との和だけ上記偏光子に対して偏光方向を傾けてあることを特徴とする。

【００１１】

【作用】ファラデー回転子は順方向と逆方向とで偏光回転角が逆になり、且つこの偏光回転角には波長依存性がある。一方、液晶回転子は順方向と逆方向とで偏光回転角が同じであり、且つファラデー回転子と同様な大きさ波長依存性のある偏光回転角を有する。したがって、ファラデー回転子の波長依存性は旋光性の液晶回転子により補償される。

【００１２】

【実施例】以下、本発明を実施例に基づいて説明する。

【００１３】本実施例の光アイソレータを図１、２に示す。両図に示すように、この光アイソレータは偏光子１、旋光性の液晶回転子２、ファラデー回転子３及び検光子４をその光軸をそろえた状態で順次配置したものであり、磁場５を与えてファラデー回転子３にファラデー効果を発生させる図示しない磁石を具えている。ここで、旋光性液晶回転子２はファラデー回転子３の偏光回転角波長依存性を補償するものである。また、検光子４は、旋光性液晶回転子２の基準波長における偏光回転角と４５どとの和だけ偏光子１に対して偏光方向を傾けてある。

【００１４】ここで、旋光性液晶回転子２とは、通過する光を常に同方向へ回転する特性を有するものである。すなわち、基準波長の光は図１(A)に示すように順方向に通過する場合にはαだけ回転を受け、図１(B)に示すように逆方向に通過する場合には順方向の回転方向を基準にすると－αだけ回転を受けることになる。また、旋光性液晶回転子２の偏光回転角が波長に依存し、ファラデー回転子３の波長依存性を補償するように設定している。つまり、ファラデー回転子３と旋光性液晶回転子２の波長に依存した偏光回転角の増加（減少分）を同一にしておくことにより、例えば図２(A)に示すように順方向では基準波長より２δだけ余分に回転させられるが、

図２(B)に示すように逆方向ではファラデー回転子３と旋光性液晶回転子２とで波長依存性が相殺されることになる。

【００１５】旋光性液晶回転子２の一例としてのツイスティッド・ネマティック（ＴＮ）液晶は、次式で示される光の通過率Ｔを有している。

【００１６】

【数１】

$$T=\frac{\sin^2\left(\frac{\pi}{2}\sqrt{1+u^2}\right)}{1+u^2}$$

【００１７】ここで、ｕ＝２ｄΔｎ／λであり、ｄは液晶の厚さ、Δｎは屈折率差、λは光の波長である。上式より光の透過率が波長により異なっていることがわかるが、これは偏光回転角が波長に依存するためである。すなわち、この性質を利用することにより、上述したように、ファラデー回転子３の波長依存性を補償することができる。そして、旋光性液晶回転子２の厚さは、水晶回転子に比べて二桁程度小さくすることができ、光アイソレータ自体の小形化を図ることができる。なお、液晶回転子２は上記ＴＮ液晶に限定されるものではないことは言うまでもない。

【００１８】本実施例の光アイソレータに基準波長の光を導入した様子を図１(A),(B)を参照しながら説明する。図１(A)の６－１～５は順方向に進む光の偏光の様子を示し、順方向に進む基準波長の光（６－１）は偏光子１の通過によりその偏光方向に一致する光（６－２）となった後、旋光性液晶回転子２により角度の回転を受けて出力される（６－３）。そして、この光（６－３）はファラデー回転子３により同方向に４５度の回転を受け、通過後には偏光子１の偏光方向に対してα＋４５度だけ回転した光となっている（６－４）。よって、この光（６－４）は、偏光子１に対して偏光方向がα＋４５度だけ傾けて配されている検光子４を通過する（６－５）。

【００１９】図１(B)の７－１～４は逆方向に進む光の偏光の様子を示し、逆方向に進む基準波長の光（７－１）は検光子４の偏光方向に一致する光（７－２）のみ当該検光子４を通過する。この光（７－２）は偏光子１の偏光方向に対してα＋４５度（順方向での回転方向を基準とする。以下同じ）回転した光であり、この光（７－２）はファラデー回転子３通過後には４５度の回転を受け、偏光子１の偏光方向に対してα＋９０度回転した光（７－３）となる。そしてこの光（７－３）はさらに旋光性液晶回転子２により－αの回転を受け、偏光子１の偏光方向に対して９０度回転した光（７－４）となるので、偏光子１を通過することはできない。

【００２０】次に、基準波長と異なる光を導入した場合を図２(A),(B)を参照しながら説明する。図２(A)の８

http://www6.ipdl.jpo.go.jp/tjcontentbs...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f///////

－１～５は順方向に進む光の偏光の様子を示し．基準波長と異なる波長の光（８－１）は偏光子１の通過によりその偏光方向に一致した光（８－２）となった後．旋光性液晶回転子２により角度α＋δの回転を受けて出力される（８－３）．そして．この光（８－３）はファラデー回転子３により同方向に４５度＋δの回転を受け、通過後には偏光子１の偏光方向に対してα＋２δ＋４５度だけ回転した光となっている（８－４）。したがって、検光子４から出力される光（８－５）は検光子４の損失を無視すると．ファラデー回転子３からの出力光（８－３）に対してｃｏｓ’２δ倍の強度となる。

【００２１】図２(B) の９－１～４は逆方向に進む光の偏光の様子を示している。基準波長と異なる波長の光（９－１）のうち、検光子４を通過する光（９－２）は偏光子１の偏光方向に対してα＋４５度回転している光であり、この光はファラデー回転子３通過後には偏光子１の偏光方向に対してα＋δ＋９０度回転した光（９－３）となる。さらに、この光は旋光性液晶回転子２により－（α＋δ）だけ回転を受けるので．液晶回転子２を通過した光は偏光方向に直交する光（９－４）となるため．偏光子１を通過することはできない。

【００２２】以上説明したように、本実施例の光アイソレータはファラデー回転子３の波長依存性を液晶回転子２で補償し、入射光の波長依存性のない小形の光アイソレータといえる。なお、上記構成において、ファラデー回転子３と液晶回転子２の配置を逆にしても同様の効果が得られることは言うまでもない。

【００２３】

【発明の効果】以上説明したように．ファラデー回転子の偏光回転角波長依存性を波長に対する偏光回転角がファラデー回転子の偏光回転角に対して全く逆である液晶回転子を用いて補正しており、波長依存性のない光アイソレータを構成することができる。この際、液晶回転子の偏光回転能はファラデー回転子より大きくすることができるため、ファラデー回転子の波長依存性を補償するための厚みを薄くすることがで、それ故、光アイソレータ全体のサイズを小さくすることができる。

【図面の簡単な説明】

【図１】一実施例に係る光アイソレータを示す構成図である。

【図２】一実施例に係る光アイソレータを示す構成図である。

【図３】従来技術に係る光アイソレータを示す構成図である。

【図４】従来技術に係る光アイソレータを示す構成図である。

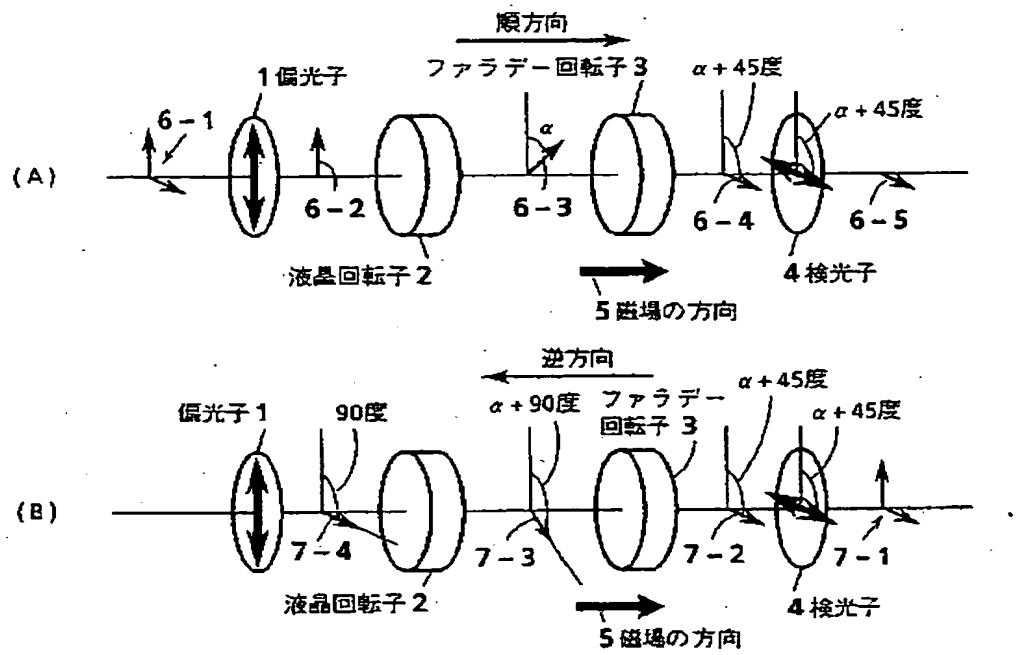
【符号の説明】

１　偏光子
２　液晶回転子
３　ファラデー回転子
４　検光子
５　磁場の方向
６　順方向入射光の偏光の様子
７　逆方向入射光の偏光の様子
８　順方向入射光の偏光の様子
９　逆方向入射光の偏光の様子

02/11/21 午前 10:00

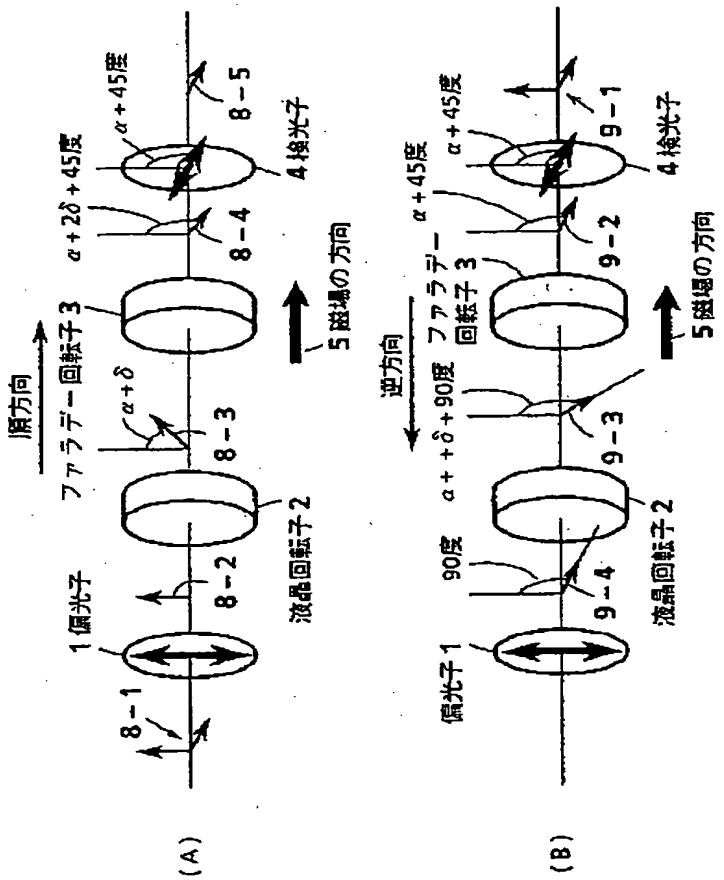
http://www6.ipdl.jpo.go.jp/tjcontentbs...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f///////

【図1】



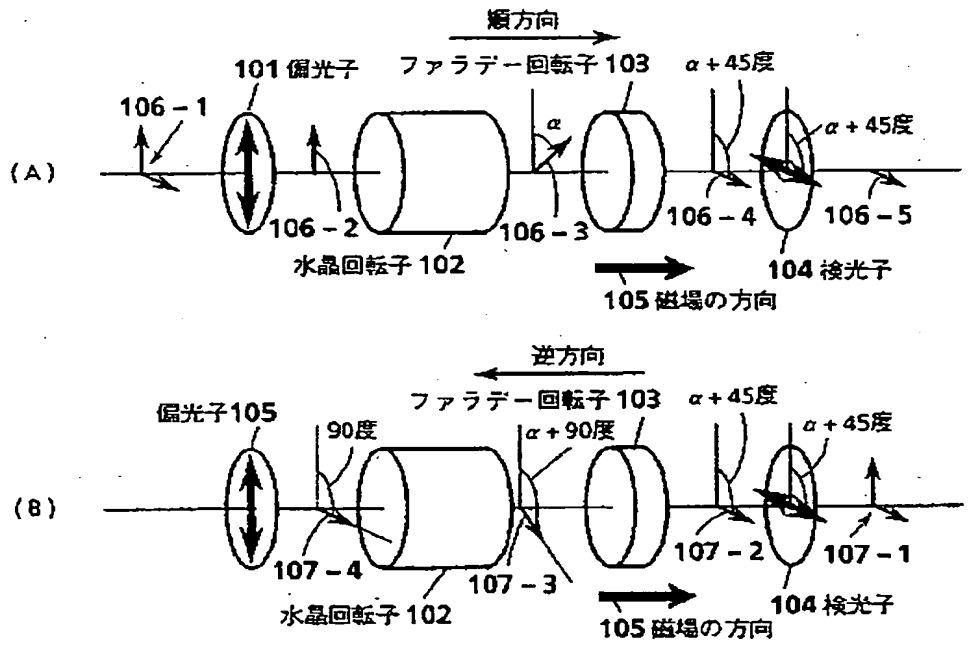
http://www6.ipdl.jpo.go.jp/tjcontentbs...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f///////

【図2】



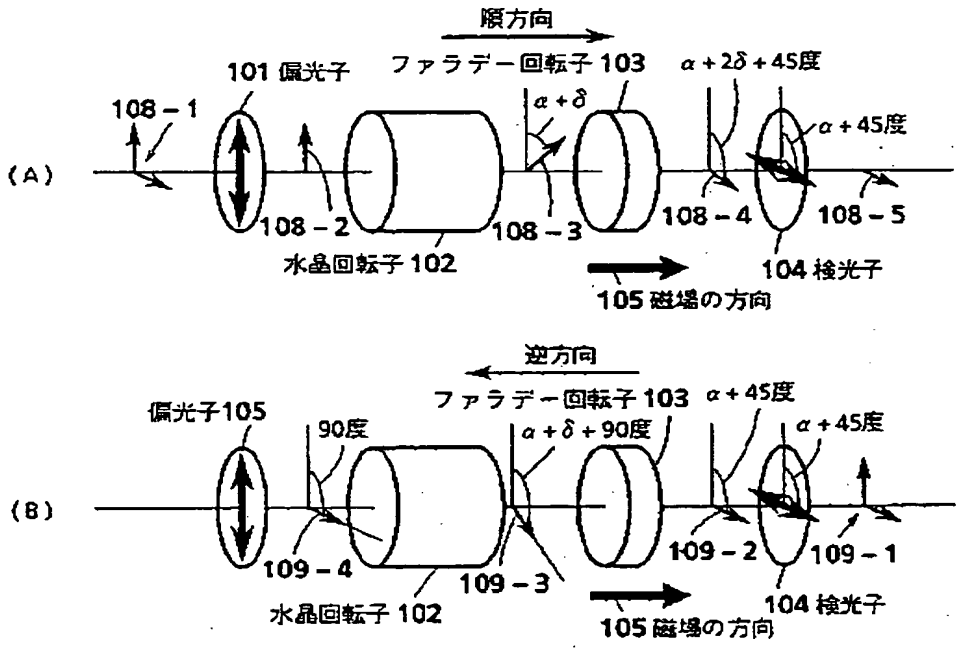
http://www6.ipdl.jpo.go.jp/tjcontentbs...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f///////

【図3】



http://www6.ipdl.jpo.go.jp/tjcontentbs...0704=1E_N/;%3f%3a=;%3e%3e%3f%3f///////

【図4】



This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☑ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: _____

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.